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Frequency and Damping Rate of the Geodesic Acoustic Mode in Collisional Plasmas

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The frequency and damping rate are two most fundamental properties of the GAM. The collisional effect could be important in the plasma edge. In our work [1], where a number conservation Krook collisional operator was used in the gyrokinetic model, it was found that the damping rate of the GAM is non-monotonic as the collision rate increases. At low ion collision rate the damping rate increases linearly with the collision rate; while as the ion collision rate is higher than v_{ti}/R, the damping rate decays with an increasing collision rate. At the same time, as the collision rate increases, the GAM frequency decreases. However, it is noted that the number-conserving Krook collision operator is rather approximate. It is of interest to investigate the eigen-frequency of the GAM using more accurate operators and thereby find which properties of a collision operator are important for the dynamics of the GAM.

In this work four different ion collision operators, including (a) a Krook operator with number conservation only, (b) a Krook operator with number and energy conservation, (c) a Lorentz operator which conserves number and energy automatically and (d) a Lorentz operator with an energy-dependent collision rate, are employed in a drift-kinetic model to investigate the collisional effect on the GAM frequency and damping rate. Comparison between different collision operators is performed as well. For operator (a), the result is the same as previously. For operator (b), the damping rate is only one ninth of that from (a). For operator (c), the damping rate approximates to that from (a) at low collisionality but give a lower damping rate than that from (b) and (a) at high collisionality. The result from operator (d) is close to that from (c). Due to finite collisional damping, the GAM frequency decreases. At very high collisionality, the GAM frequency approaches to v_{ti}/R for operator (a) but to $\sqrt{5/3}v_{ti}/R$ for other three operators. The result shows that both density and energy conservation of the collision operator are important for determining the GAM frequency and damping rate. The absence of energy conservation induces the overestimation of collisional effect at high collisionality.

[1] Gao, Phys. Plasmas 20, 032501(2013)

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